Promoting Societal-Oriented Communication and Decision Making Skills by Learning about Advertising in Science Education

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In our everyday lives we are surrounded by advertising in its various forms. Thus in the school context it is not surprising that the issue of advertising is addressed by different subjects, with the main foci being advertising-specific language, images and illustrations, use of stereotypes, strategies of persuasion etc. But advertising also contains factual information, being explicit or implicit, to make a campaign more credible and underline the effectiveness of a certain product. Dealing with the use of factual information in advertising critically is important for the consumer. For many products this information is derived from science and technology. Understanding the science in and behind advertising is necessary to become a critical consumer. Learning about the use of science in advertising also allows promoting societal-oriented communication and decision making skills in the science classroom. Unfortunately, only a few examples on the use of advertising in the science classroom exist. This paper provides a justification for the use of advertising in science education. Examples from the classroom developed in the framework of the PROFILES-project are provided by way of illustration.

Keywords: Science education, Science-technology-society, Socio-scientific issues, Communication skills, Critical media literacy, Advertising

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Promoviranje družbeno usmerjene komunikacije in sposobnosti sprejemanja odločitev prek učenja o oglaševanju v naravoslovnem izobraževanju

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V vsakodnevnem življenju smo obkroženi z oglaševanjem v različnih oblikah. Tako ni presenetljivo, da je v šoli oglaševanje obravnavano pri različnih predmetih; obravnavajo pa se predvsem: specifičen jezik oglaševanja, podobe in slike, uporaba stereotipov, strategij prepričevanja … Vendar oglasi vsebujejo tudi dejanske podatke oz. informacije, ki so eksplicitno ali implicitno podane; z njimi skušajo podkrepiti kredibilnost in poudariti učinkovitost nekega izdelka. Kritično analiziranje podatkov, informacij v oglasih, je za potrošnike pomembno. Veliko teh podatkov oz. informacij je pogosto pridobljenih iz naravoslovja in tehnologije. Da bi postali kritični potrošniki, je pomembno razumevanje naravoslovja v oglaševanju. Učenje o uporabi naravoslovja v oglaševanju pripomore tudi k promoviranju družbeno usmerjene komunikacije in sposobnosti odgovornega odločanja v razredu. Žal poznamo le nekaj primerov uporabe oglaševanja v naravoslovnem poučevanju. V prispevku argumentiramo upravičenost uporabe oglaševanja v naravoslovnem izobraževanju. Prikazani primeri so nastali v okviru projekta PROFILES.

Ključne besede: naravoslovno izobraževanje, naravoslovje – tehnologija – družba, socionaravoslovne teme, sposobnost komuniciranja, kritično presojanje medijev, oglaševanje

Background

For the first time ever, nationwide standards for lower secondary science education were applied in Germany in 2004 (KMK, 2004). The standards led to various reforms and initiated constant debate about curricula and pedagogies appropriate for science education. More student-centred and inquiry-based science teaching, methodological variety, and a more thorough use of meaningful contexts to promote more effective and situated learning were demanded. Part of this movement is a stronger focus in science education on promoting general educational skills which has parallels in many countries, especially with a focus on preparing the young generation for their life today and in the future in a changing world (Aikenhead, 2007; Burmeister, Rauch, & Eilks, 2012; Roth & Lee, 2004).

A greater societal orientation of science education is suggested for better preparing students for living in society (Elmose & Roth, 2005; Hofstein, Eilks, & Bybee, 2011; Ware, 2001) and to raise their perception of relevance of science education (Fensham, 2004; Lee & Erdogan, 2007; Stuckey, Hofstein, Mamlok-Naaman, & Eilks, 2013). There is a need for change towards more societal-oriented science education and a more thorough focus on argumentation and decision-making skills gains growing support from different theoretical resources. In the German-speaking realm, this view coincides with the concept of *Allgemeinbildung* (Hofstein et al., 2011; Marks, Stuckey, Belova, & Eilks, 2014), defined as the educational upbringing of students to be responsible citizens characterized by the abilities of self-determination, participation, and solidarity in a democratic society (Klafki, 2000). This specific German view is in accord with an understanding of scientific literacy as being multidimensional (Bybee, 1997), or rethinking traditional science education from a "*Science through Education*" approach, in order to adapt science lessons into a program of "*Education through Science*" (Holbrook & Rannikmäe, 2007) – as it is represented also be the "ES" in the acronym PROFILES. But even though the debate in Germany has been going on for almost ten years now, learning about the interrelationship between science and society seems still to be insufficiently implemented; this is also the case for other countries, as discussed by Hofstein et al. (2011).

In the German Federal State of Bremen, the science education debate came to a climax when a new type of secondary comprehensive school, the "Oberschule", was recently implemented. In this context science was transformed into an integrated subject for students from grade 5 to 8 (age 10-48 14) where Chemistry, Biology and Physics formerly were taught as being three separate subjects. The new governmental science syllabus has now been structured

by different contexts which should promote student-active and problem-based learning. A thorough societal orientation has also been emphasized. As a consequence, teachers were not only supposed to deal with a new type of school but also with a new subject and curriculum. For that reason the continuous professional development (CPD) program in Bremen, operated within the framework of the EU-funded project PROFILES (Bolte et al., 2011), focused on "Oberschule" teachers. PROFILES in Bremen undertook an Action Research driven development as a strategy for teachers' CPD, aiming at implementing inquiry-based and societal-focused science education (Schindler et al., 2014). Part of the development focuses on the use of advertising in science education.

A theoretical framework for operating advertising in science education

Within the framework of more societal-oriented science education one sub-set of innovations focuses the use of socio-scientific issues (SSI) in the science classroom (Sadler, 2004, 2011; Zeidler, Sadler, Simmons, & Howes, 2005). SSI's should not only serve as a motivating context for science learning, but also as a catalyst to promote general educational skills through science education, especially argumentation and decision making skills (Albe, 2008; Simon & Amos, 2011).

The SSI-movement in science education has emerged from different curricular approaches, especially the Science-Technology-Society framework (e.g. Solomon & Aikenhead, 1994; Yager & Lutz, 1995). In recent years, this movement has suggested that students need to learn more intensively about how science is interacting with society and its related problems (Sadler, 2004). In a democratic society, every citizen is asked to contribute to the respective debates and decisions, even if the citizen is not an expert in science or technology (Hofstein et al., 2011). Learning about the use of science in societal debates should be seen as important to enable learners to become future responsible citizens (Roth & Lee, 2004). Students should learn to cope with their life individually within the society in which they live, but also to participate actively in societal discourse concerning SSIs (Sjöström, 2011).

Within the SSI-based science education movement some ten years ago, the socio-critical and problem-oriented approach to science education was developed in Germany (Marks & Eilks, 2009; Marks et al., 2014). Today, the approach and its corresponding curriculum model has been introduced in a large variety of different lesson plans for science education, e.g. on low-fat- and low-carb diets (Marks, Bertram, & Eilks, 2008), musk fragrances in shower gels (Marks &

Eilks, 2010), the use of bioethanol as an alternative fuel (Feierabend & Eilks, 2011), or the evaluation of conventional and alternative sorts of plastics (Burmeister & Eilks, 2012). The socio-critical and problem-oriented approach to science education focuses on increasing learners' motivation and perception of relevance in science teaching, as similar approaches do (Osborne, 2003; Holbrook & Rannikmäe, 2010). It attempts to explicitly prepare students for understanding and taking part in societal consensus-building and decision-making processes on techno-scientific queries as suggested by e.g. Feierabend and Eilks (2011) or Burmeister and Eilks (2012). The approach attempts to construct a consistent curriculum model to operate SSI-based science teaching and is operated using a five stage model for each of the curriculum units (Marks & Eilks, 2009), which has parallels to the three-stage model by Holbrook and Rannikmäe (2012) described in the theoretical framework of the PROFILES-project.

In this curriculum model, the introduction to the topic is undertaken by the use of authentic media artefacts, e.g. newspaper articles, brochures printed by pressure groups, reports broadcasted by TV stations, and of course advertising. The topics need to allow for real decisions to be negotiated. Issues are inappropriate whenever only one-sided solutions are possible or which are not openly debatable due to scientific, ethical, or sociological reasons (Marks & Eilks, 2009). Activities within the lesson plan challenge the students to make up their own minds and express their opinions on the topic in an open forum. Such conditions make it possible to express one's personal point-of-view without being judged, censored or condemned as an outsider by the rest of the group. The reflection on how society is handling and evaluating the SSI is undertaken by mimicking an authentic societal practice of dealing with respective issues. Different methods are suggested, which allow contrasting societal perspectives on the topic and societal decision making processes. These can include conventional elements like role-playing and business games (Feierabend & Eilks, 2011) or more innovative pedagogies as working like a journalist (Marks, Otten, & Eilks, 2010), a professional product tester (Burmeister & Eilks, 2012), or advertiser (Stuckey, Lippel, & Eilks, 2012).

In the German national standards for science education at the lower secondary level, two of the four domains of competencies, which students are asked to develop, are evaluation and communication competencies. Communication – in particular argumentative communication – is the essential mediator of discourse and debate in society (Nielsen, 2013). Debate in society takes place in public discussions, parliaments, the Internet, other mass media, or personal communication. It is influenced by communications in newspapers, digital media, publications by interest groups and political stakeholders, and certainly

advertising. The individual as a responsible citizen has to have skills to evaluate and to respond to this kind of information to make up her or his mind and to participate in the debate – both with the presented information as well as with the way the information is presented to him (Hofstein et al., 2011). Dealing with advertising in the science classroom, therefore, is necessary to show the students how this medium deals with scientific information and how it presents this information to the public. Furthermore, advertising itself is a very special form of mass communication (O'Guinn, Allen, & Semenik, 2012), which students need to learn to understand.

What is special about advertising is that, besides being used as a medium for learning ("learning *with* advertising"), it can also be the SSI itself ("learning *about* advertising"). Not only can we motivate certain scientific topics with appropriate advertising, we can also discuss the scientific information used in advertising, how it is presented, which effect it has on the credibility of the advert, whether wrong and misleading information is used, etc. Recently Stolz, Marks, Witteck and Eilks (2013) and Eilks, Nielsen and Hofstein (2014) suggested five criteria, in an operationalized form, to justify whether a topic from society might become a good classroom context to promote general educational skills in the framework of SSI-teaching. These criteria can be well applied to advertising, justifying advertising itself to be a good SSI for the science classroom, as it is outlined in Table 1.

Table 1. *Criteria for reflecting potential topics with respect to the socio-critical and problem-oriented approach to chemistry and science teaching, illustrated using the example "Advertising".*

Criterion	Description and testing	Example: "Advertising"
Authenticity	The topic is authentic, because it is currently being discussed by society. *Test*: The topic is checked for media presence in the everyday newspapers, magazines, TV, advertising, etc.	Advertising is all around us. We are confronted with various forms of advertising daily (print, TV, internet etc.). Misleading advertising or false promises is a frequent cause of discussion in society. Many adverts are directly aimed at young people.
Relevance	The topic is relevant, because any societal decision in this area will affect the current or future lives of our students. *Test*: Scenarios on potential societal decisions are tested to see which options emerge for individuals to decide for themselves in the sense of consumption and behavioral choices.	Political decisions on advertising (like the recent EU regulation on health claims) affect the way a product is presented to the consumers and therefore impacts the consumption choices of the individual.

Open evaluation situation with respect to a societal relevant question	Societal evaluation is open and allows for different points-of-view. *Test*: Everyday life media is analyzed out to see if controversial viewpoints are represented (by special interest groups, the media, politicians, scientists, etc.).	The public discussion about advertising is strongly dominated by stakeholder groups (companies, consumer protectors, politicians, etc.). The debate centers around advertising laws and regulations being too strict or too permissive concerning the gap between consumer information and manipulation.
Allows for open discussions	This topic is able to be discussed in an open forum. *Test*: Thought experiments are used to test opinions stating various points-of-view. The resulting arguments are checked to make sure that no individuals, religious or ethnic groups would feel themselves to be insulted or pushed to the fringes of society by their use.	It is possible to discuss the legislation around advertising in the public forum. EU-politicians, industry representatives and consumers discuss this topic from wide-ranging, controversial viewpoints. Should advertising take more responsibility with respect to its societal influence? How do companies use loopholes in the legislation for misleading advertising? In which way are studies that prove the effectiveness of a product conducted?
Deals with an issue based on sciences (chemistry) or technology	This topic concerns itself with a techno-scientific query, which contains scientific facts and the networks between them at its most basic level. *Test*: Discourse in the media is analyzed. The question is raised, whether scientific concepts are addressed and either explicitly or implicitly used for argumentation.	Advertising for many everyday-life products uses scientific information to show how effective a product is, e.g. in domains like cosmetics, foods, mobility, or cleaning agents. While new products are developed with the participation of scientists, advertising agencies often don't employ experts in the fields of science so the information is often presented in a distorted, simplified, whitewashed, or misleading way.

Speaking about scientific information, one has to be aware that the information presented to us through different channels is no longer authentically scientific, whether the source is TV, radio, newspapers, brochures, or advertisings (Eilks et al., 2014). Every citizen is confronted with this kind of altered information, or better named 'filtered' information (Hofstein et al., 2011). Everyone has to deal with it and make up her or his mind. In other words, for every non-scientist, the way suitable information for understanding a socio-scientific issue takes is very long and indirect. In a series of single steps, the original information is processed and filtered from one domain to another, but also within the domains. This is done by individuals or groups through processes of selecting, simplifying, and interpreting the information in each of these steps. This process is illustrated by Eilks et al. (2014) through a model shown in Figure 1.

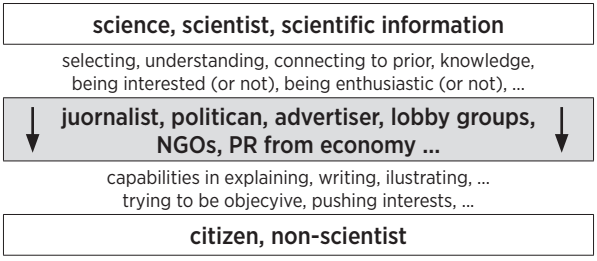


Figure 1. The doubled filtering process of scientific information transfer.

The further we move from science towards everyday life, the more the information most probably is filtered and altered. The further we leave the domain of authentic science itself, the greater the chance that the persons involved do not apply comprehensive subject matter knowledge necessary for securing reliability of the information transfer. As a result, the interaction with science-related information in everyday settings does not just need a simple evaluation of the pertinent scientific facts. Frequently, it is just as – if not more - important to understand which pathway the information followed and which interests have played a role in its transfer.

In the case of advertising, one can certainly assume that any information used will be very strongly filtered. To begin with, advertising slogans or spots are, in most cases, very short. The information provided and the whole setting must convince the consumer to buy the product, and of course the main interest is not objective product information. Figure 2 shows the filtered-information-model adapted for advertising. One can see that the actors involved are not science experts, even if bigger advertising agencies sometimes also employ experts from the natural sciences or technology. As evidence for a lack of expertise, advertisements often contain scientific information that is simply wrong. A prominent example is a big German cosmetic corporation that recently launched a campaign for a deodorant containing "silver molecules." After several months of heavy broadcasting, a critical response grew on the internet and the slogan was changed to "silver ions."

Seen altogether, we have shown the movement of SSI-based science education and the model of a socio-critical and problem-oriented approach to science teaching (Marks & Eilks, 2009) with its parallels to the PROFILES three-stage-model for curriculum modules (Holbrook & Rannikmäe, 2012). Together with the ideas of mimicking authentic societal practices and filtered information to learn about science-related information transfer and use in society, we have illustrated a substantive framework that justifies interaction with advertising in science education, both from a scientific and societal view.

Figure 2. The doubled filtering process of scientific information transfer in advertising.

Learning about advertising in science education – scenarios and examples

Only very little can be found in the literature on the use of advertising in science education. In the case of Germany, a thorough literature review of educational journals from all available domains showed that advertising is primarily a topic of language education (Belova & Eilks, 2014). The main foci lie in advertising language, cultural references in advertising and stereotypes. A search in the NCTE-database (National Council of Teachers of English) showed similar tendencies for English language education in the US, although most of the papers dated back to the 80s (e.g. Frazier et al., 1985). UNESCO emphasizes the language aspect in learning about advertising, too, even defining "advertising literacy" as a part of media literacy (UNESCO, 2011). The UNESCO curriculum also addresses the role of commercial forces in the media landscape in general, advertising placement and regulations, political advertising, the evaluation of claims, as well as advertising design (UNESCO, 2006, 2011). However, in all the literature, there is a lack of a perspective on the factual content and its reliability. Though terms, like "misleading claims," do appear in UNESCO curricula, these are not connected with a reflection on the use of any scientific information and background.

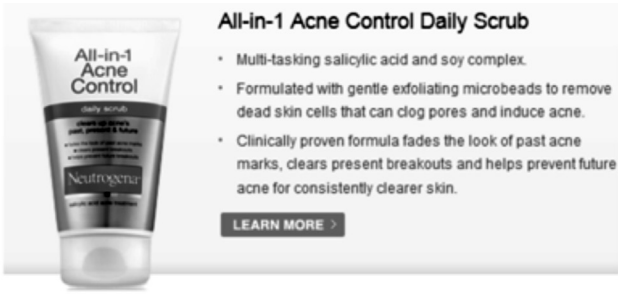
Only very few science education papers were found dealing with aspects of advertising. In the case of Germany, advertising so far is only suggested to play a role as an introduction to a certain topic, a data- provider for tasks, or an inducement for experiments where claims have to be experimentally tested (Belova & Eilks, 2014). In all these cases, advertising is used to contextualize science learning, a reflection on advertising itself is rarely put into question. Also, in the international literature, there are very few papers on advertising

in the science classroom. Scheibe and Rogow (2012) provide rough teaching ideas on advertising in their book on media literacy. They suggest, namely, the examination of advertising and other media, in relation to the image of science, or experimental testing of scientific claims. McSharry and Jones (2002) also suggest the potential of advertising for science education and conclude that it is a very fruitful medium in the science classroom, but also without specific teaching ideas. Only very few ideas go further. For example, Stuckey et al. (2012, 2014) reported the motivating potential of chemistry lessons on sweeteners in which the students are supposed to create an advert themselves and reflect on the role of the scientific information involved (also with respect to a certain target group).

Based on the existing literature, Belova and Eilks (2014) suggested four potential scenarios for including advertising in the science classroom. The scenarios differ in their complexity and contribution to critical media literacy:

Motivation and illustration: Advertising is used as an illustrative opening towards a new topic with advertising being mainly used for motivation purposes. An example for this scenario is discussed in Stolz et al. (2013) and concerns a lesson plan on doping in chemistry education. A print advertising on shampoo against hair loss is used which is described as "Doping for the hair." The advertising is used to introduce the term "doping" and to motivate the students to think about it. The advertising itself is not further discussed in the lessons since the lessons take another focus.

Contextualization for scientific inquiries and tasks: In this case, advertising is used to contextualize scientific inquiries and learning. Advertisements are used to provoke science-related questions and inquiries which often result in experiments (e.g. von Borstel, Böhm, & Hahn, 2006). From the advertising, the students are asked to formulate questions on the reliability of the given claims and then to develop scientific inquiries to answer them. An example is presented in Figure 3. Similar uses are described in the case of mathematical tasks in physics education by Vogt (2011).



A scrub is a cosmetic product which helps to remove dead skin cells. Scrubs sold in drugstores are mostly mechanical scrubs. That means that they contain small particles which clear the skin. In advertisings it is often promised that a scrub is very gentle and can be used even daily, even if the skin is sensitive. So is your scrub really that "gentle"? Simple tests will help you to find out.

1) **Apply a pea-sized amount of the product on a spot plate and determine the pH-value of the product with the help of indicator paper. Compare this value with the pH of your skin.**
2) **Put on a thin layer of scrub on a slide and look at it under the microscope. Can you see the solid particles? Describe what you see!**

Figure 3. An experimental task on facial scrub advertising. The students are supposed to confirm the slogan stating that the product is very "gentle" and can be used every day. (Image taken from www.neutrogena.com)

Reflecting the role of how science-related information appears in advertising: This approach suggests analysis on how science and technology-related factual content appears in advertisements. The reflection concerns the intention of using science-related information in advertising to support claims, but also how they might contribute to misleading or suggestive advertising, by truncated, falsified, or false scientific information. An example for this role can be found in Jungbauer (2009) who suggested reflecting advertising, in which health supporting claims are not sufficiently evident.

Meta-cognition on the interplay of science and advertising: In this approach, a thorough socio-scientific skills-oriented perspective is suggested. This perspective puts the interaction of science and technology with advertising into focus and thus includes questioning the transfer of information about science and technology to advertising. The difference that makes this role most relevant for multidimensional media literacy is that advertising itself, the development of it, and the principles behind it are addressed explicitly and connected with the scientific content. One example is described by Stuckey et al. (2012). They suggest a chemistry education module where the students themselves create advertising in order to question what kind of role subject-related information can (and should) play (possibly considering a specific audience).

Implementing advertising into science education within PROFILES Bremen

Inspired by the lesson plan by Stuckey et al. (2012), pedagogies and further examples on the use of advertising in science education were developed by groups of teachers within the PROFILES project in Bremen. The development took place with teachers, in cooperation with science educators, following the model of Participatory Action Research in science education, as suggested by Eilks and Ralle (2002). One of the pedagogies developed within this framework was the so-called "advertising method." Students receive pre-selected information about a product. The first step is to sort the information into positive and negative information – scientific-technical (using scientific knowledge) and other (such as economic). Based on the analysis of the information, the students, in small groups, create their own advertising. They select potentially the most fruitful set of information concerning a product for a certain target group. During the presentation of the advertisements created, the students reflect on which advertisements are the most convincing and for what reasons. It is discussed whether inclusion of scientifically-based information is reasonable in an advertisement for a specific target group and whether this might be a different case for different products and target groups. From the practical implementation, such an activity was seen as very motivating and led to intense discussions. An example for information on natural cosmetics is shown in Figure 4.

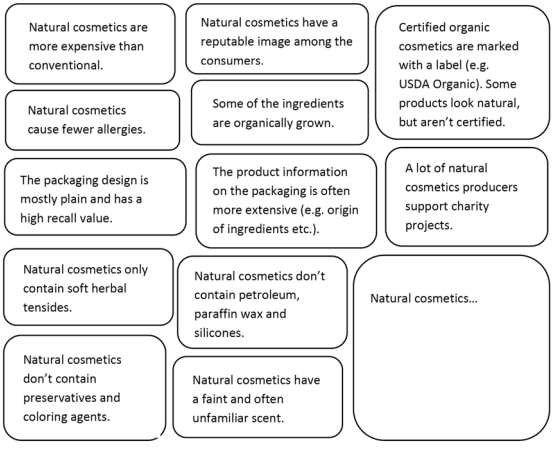


Figure 4. Possible pre-selected promotional information about natural cosmetics. The students evaluate the statements on their suitability for advertising. First, negative or potentially negative statements have to be sorted out. Of the positive or apparently-positive statements a selection must be made with regard to the target group.

Another method was also developed: "reflecting slogans" (Eilks et al., 2012). In this method, the students receive a selection of real slogans for a specific product. Along three scales, the students evaluate these slogans, namely regarding credibility, attractiveness, and its relationship to the scientific information behind them (using their gained science knowledge). The students realize the different perceptions in different advertising slogans. Discussion is initiated on which of the slogans are based on scientific facts, or address scientific thinking (based on prior science conceptualisations). Reflected also is the role science-based information plays, how it is selected and displayed, and whether it affects the credibility and/or attractiveness of advertising in a positive or negative way. An illustration of this method is given in Figure 5.

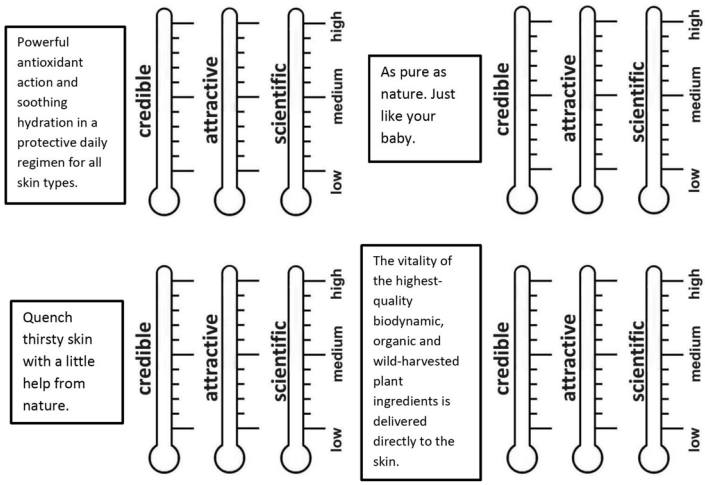


Figure 5. Advertising slogans for natural cosmetics (excerpt from a corresponding worksheet). The students evaluate the credibility, attractiveness, and science relatedness of advertising slogans.

A combination of different activities on advertising in science education was also developed as a case study within PROFILES, on a lesson plan on cosmetics (Stuckey et al., 2012). In this, advertising is first of all used as an authentic and motivating introduction to the topic, but this time, also, as a starting point for scientific inquiry. The students are confronted with slogans like "pH-neutral," or "skin friendly" and inquire into their meaning through different experiments (which may be suggested by the students). The authentic advertising at the beginning is used for motivation for the topic. Slogans contextualize scientific inquiry on cosmetic products. Finally, reflection on information like

"pH- neutral" and "skin friendly" are discussed to decide whether they are scientifically reliable for the cosmetic products and why they are used.

However, the module also incorporates a fourth scenario. In the practical work, the students make their own cosmetic product, a body lotion. At the end of the module, the students develop an advertising campaign for their self-made product. To aid this, the students watch different TV spots on related products, which are judged with the help of a list of criteria (Figure 6). The criteria raise the students' awareness for scientific aspects in advertising and help them set priorities in their own advertising. At the end, the advertisements are produced, compared and discussed as indicated above.

Product / Criterion	A:	B:	C:
General			
Do you know the brand?			
Do you know the product?			
Have you used the product before?			
Scientific aspects			
Scientific terms in the advert			
Scientific terms in the packing			
Scientific images/charts/graphs in the advert			
Study results in the advert			
Study results on the packaging			
Survey results in the advert ("9 out of 10 women ...")			

Figure 6. Criteria for judging scientific aspects in the presentation (advertising, packaging) of a product (excerpt from the corresponding worksheet).

Implications

More than a decade ago, McSharry and Jones (2002) concerning science in advertising draw a fairly harsh conclusion:

> "*The majority of people watch television and buy products which are advertised on it, but do not realize that these products are science-based. […] If the great majority of people are unable to relate their own experience to forms of science then science education has failed to provide them with a great deal of useful information for their lives.*"

Until today, the issue of advertising is underrepresented in the science education literature, although other media types are more and more widely used in the science classroom. E.g., news from newspapers, television, as well

as from the Internet, are often suggested when it comes to science educations' contribution to media literacy. Being capable of engaging with, and arguing about, science-related news critically is seen as a requirement for being a modern citizen (Elliott, 2006; Hodson, 2008; McClune & Jarman, 2010). Fictional television shows with a scientific background, as well as documentaries or writing news about science, are also suggested for implementation in schools (Dhingra, 2003; Marks, Otten, & Eilks, 2010).

This paper suggests that the use of advertising in science education can contribute the development of a multidimensional scientific literacy. This paper shows that its application can be well justified and conducted in multiple ways. Objectives encompass both focusing scientific inquiry and content knowledge, but also contributing to critical media literacy, as well as socio-scientific communication and decision-making skills. Advertising is a highly authentic and in many cases also motivating medium. Dealing with advertising opens up new opportunities for social contextualization in the learning of science and technical content. Innovative and student-oriented pedagogies, some of which are presented in this paper, can help counteracting the lack in the perception of relevance among students in the science subjects. First trials of using advertising in the science classroom within the PROFILES project show intense discussions and high student motivation (Stuckey et al., 2012).

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